MDE Product Development Team
November 2009 - FY10 Monthly Report
Submitted 15 December 2009

With contributions from Geoff DiMego and Mary Hart (NCEP/EMC);
Stan Benjamin, John Brown, Steve Weygandt (NOAA/ESRL/GSD);
Jordan Powers, Roy Rasmussen (NCAR);
And Ming Xue (OU/CAPS)
(Compiled and edited by S. Benjamin and B. Johnson)

Executive Summary

Rapid Refresh / RUC Technical Review at ESRL – Tues 3 Nov 2009 – 160-slide presentation – **http://ruc.noaa.gov/pdf/RR-RUC-TR_11_3_2009.pdf** . This PowerPoint contains information on RR and HRRR progress. Also now available is the RR/RUC (Benjamin/Weygandt) and Mesoscale (DiMego) presentations from the NCEP Production Suite Review, presented 8 Dec 2009 – **http://www.emc.ncep.noaa.gov/annualreviews/2009Review/index.html**

Task 10.5.1: Infrastructure support related to operational running of the RUC and NAM operational modeling systems.

- Testing continues at NCEP for 18h RUC/Canadian data, implementation now scheduled for Feb.
- TAMDAR thinning from limited NOAA funding has reduced RUC accuracy starting in late October.

Task 10.5.4 Develop, test, and implement Rapid Refresh configuration of the WRF modeling system.

- Partial cycling for Rapid Refresh running in primary 1-h cycle at GSD, giving much improved results
- Ceiling forecasts (MVFR, IFR) from RR now exceeding those from RUC (in addition to wind and temperature, as reported last month).
- Overall performance of the RR is now generally suitable for implementation of the RR. Transfer to NCEP has started, and discussions between ESRL and NCEP are now becoming much more frequent.

Task 10.5.5: Develop, test, and implement 3DVARs for RR and NAM

- RR GSI – further testing

Task 10.5.17: Infrastructure support for NAM, future RR, future HRRR, support for community WRF model

- WRFv3.2 nearing readiness. Contributions from NCAR to WRF model, especially on WRF physics.

Task 10.5.15: Develop methods for improved cloud/hydrometeor analysis in RR

- Ceiling forecasts from RR now matching or exceeding those from RUC, due to improvements to RR cloud/hydrometeor analysis

Task 10.5.24/19: Development/testing of HRRR

- HRRR continues to run over full CONUS domain, examination of winter season fields underway.

Task 10.5.1 Infrastructure Support Related to Operational running of the non-WRF Rapid Update Cycle System in NCEP Operations

GSD

- General monitoring of operational RUC at NCEP, inter-comparisons with backup RUC, dev RUC run at ESRL.
- Monitoring TAMDAR availability for RUC. Comparisons of RUC forecast skill and TAMDAR counts between different RUC versions (oper-NCEP, backup-ESRL, dev-ESRL)
    - Noted beginning of TAMDAR thinning starting 10/28 by about 90%.
        - About 60-90% of the TAMDAR temperature forecast improvement is lost from the thinning (compared to the devRUC, where all TAMDAR data is used), and about 90-95% of the TAMDAR moisture forecast is also lost from the thinning.

NCEP

Dennis Keyser reports that NCEP Central Operations (NCO) is investigating radiosonde sites that report an invalid instrument type. Still waiting for NESDIS to respond to two problems, the GOES 1x1 field-of-view cloud data (where a few random files have data problems) and the late arrival of GOES-East data. NCEP plans to obtain all TAMDAR data from AirDAT as a MADIS alternative and add airframe type and company code to allow improved bias corrections to be developed. NCEP continues work toward moving the NRL-based aircraft QC code into production. Changes are being made to speed up the dump processing in order to reduce the extra time used by this new QC code. An updated version of the NCEP BUFR library software is being tested for implementation in FY2010. The last recorder on the DMSP F-13 satellite failed on 19 November, and now SSM/I data are no longer available (including SSM/I oceanic precipitable water assimilated by the RUC). Efforts are ongoing to bring in SSM/ARE data from DMSP F-16 and F-17. The Colorado and Minnesota DOT mesonet providers were down for most of the month. The number of CWOP/APRSWXNET and AWS mesonet obs increased by more than 50% after 4 November when their temporal frequency increased from 15 to 5 minutes.

NCO was notified this month by EMC and GSD that radar reflectivity analyses were not getting into the RUC. NCO determined this was due to a “prod vs. para script switch” that occurred inadvertently when the new P6 computer became production in August. This “broke” the generation of the Level-II reflectivity mosaic used by the RUC in its diabatic digital filter initialization. NCO’s Chris Magee filed corrective Requests for Change (RFC).

Geoff Manikin reports that work is underway to extend all RUC cycles and the accompanying output to 18 hours. Code has been tested and delivered to NCO. The change package also includes code to assimilate Canadian aircraft observations and a correction to a problem with virtual potential temperatures not being adjusted in response to changes in mixing ratio associated with cloud building. This package is scheduled for implementation in Quarter 2 of FY2010.

Task 10.5.17 Infrastructure support for operational running of Rapid Refresh, North American Mesoscale, and HiResWindow (and future HRRR) at NCEP, including support for community WRF model

GSD

Progress in Rapid Refresh development toward upcoming implementation at NCEP over next few months as experimental RR cycle for testing before final submission to NCO for operational implementation next May-June.

NCEP

Eric Rogers continued running the NEMS-based NDAS/NAM real-time parallel system on the CCS. An important fix was installed to turn on gravity wave drag/mountain blocking in the NMMB, which was inadvertently turned off

due to a logic error in the code. New observation types (NOAA-19, METOP-IASI, and MODIS AMSUA_AQUA radiances, ACARS humidity, and oceanic wind scatterometer (WDSATR)) were turned on in the GSI analysis.

The NDAS/NAM/DGEX bug-fix bundle was implemented into operations on 3 November 2009 as scheduled.

Since many obs-processing activities listed under Task 10.5.1 also pertain to NAM, they are not duplicated here. For the NAM specifically, Dennis Keyser reports that some Alaskan radiosonde sites still need to move up their launch time so the NAM-GSI can use their data. Mobile synoptic data were not available from 12-18 November due to provider site issues. The SSM/I oceanic wind speed product is no longer available for assimilation into the NAM-GSI due to the 19 November demise of SSM/I on DMSP F-13 (see Task 10.5.1). A processing change at JMA resulted in no MTSAT-1R satellite derived winds from 15–27 November. The NAM-GSI normally uses a small number of IR and visible JMA winds on the edge of its analysis domain. The following data types are monitored by the NAM-GSI: RASS virtual temperature profiles (NPN and MAP), Mesonet mass data, and MDCRS moisture data. NOAA-19 1b radiances will soon also be monitored. Lower P6 Level II 88D radar data dump counts (vs. their P5 counterparts) are being investigated. We are generating NAM/NDAS PrepBUFR files with 50 km ASCAT and WindSat scatterometer wind data (both non-superobed) and NAM/NDAS dumps of METOP IASI radiances, GPS-RO data and SBUV-2 data. These changes to obs monitoring are being tested in the real-time parallel NDAS/NAM. Using the GFS tropical cyclone relocation procedure (for medium to strong tropical cyclones) to update the global first guess fields input to the t-12 hour NDAS is being tested as a possible replacement for the current synthetic wind data bogus. A legacy restriction (that only surface data with a reported pressure is processed) will be removed to allow many new surface observations (land, marine and Mesonet) to be assimilated in the RTMA and possibly NAM/NDAS. The parallel RTMA is now testing observational data dumps generated from a geographical domain which includes Guam in addition to the existing expanded NAM domain.

Matt Pyle reports that an RFC was submitted for the HiResWindow model to raise the interface pressure between the terrain-following and isobaric portions of the WRF-NMM hybrid vertical coordinate from 420 hPa to 300 hPa. The Alaskan WRF-NMM run failed in the model integration for several cycles beginning with 20091112/18Z. The root cause was found to be a deep low pressure system coincident with some very high (> 4500 m) model terrain. This combination generated very thin model levels near the surface, which generates instability when combined with a strong flow. Raising the interface pressure provides a larger portion of the atmosphere to the terrain-following portion of the vertical coordinate, generating somewhat thicker near-surface layers and preventing the instability from being generated for this case. This change is scheduled to be implemented on 8 December 2009.

During her AWC visit (see Task 10.5.20), Yali Mao collected information on the AWRP FIP and CIP modules. Because the AWRP modules were developed by different groups, they use different libraries and different Linux environment variable settings. The operational AWRP modules are installed and running on multiple Linux servers at AWC. These issues will not prevent Yali from getting the intermediate data needed for future verification after the module transition is done. Yali was also able to find contacts who can answer questions about the AWRP icing module. She has been able to figure out the procedure for installing and running FIP modules, and started reading the core icing algorithm parts of the FIP code.

NCAR/MMM

CURRENT EFFORTS: NCAR/MMM implemented WRF code modifications and worked on improvements in WRF physics. The YSU PBL scheme was improved for conservation of water and generalized for future extension to mixing more variables. The new code from developer Hong (Yonsei University) was added to the WRF repository.

Dudhia (NCAR/MMM) worked on updating the WSM (WRF single moment) and WDM (WRF double moment) microphysics schemes. The schemes are being modified to use a Lagrangian, rather than a

time-splitting approach for handling fall terms. This is more efficient at low resolution where time-splitting is more costly.

Dudhia worked on the addition of a new thermal roughness formulation from Fei Chen (NCAR/RAL). This formulation would apply to the surface layer options sfclay and myjsfc.

Dudhia and Wei Wang (NCAR/MMM) tested ideas for improving the handling of shallow convection over the ocean. The shallow convection treatment is aimed at situations where WRF can over predict PBL moisture and low clouds over marine areas.

Lastly, Dudhia continued to work with Steven Cavallo (NCAR/MMM) on improving the model-top radiation. Cavallo is addressing the RRTM longwave scheme so that the model top does not cool unrealistically, a problem related to the treatment of downward longwave radiation from above the top.

PLANNED EFFORTS: The support of the physics component of the WRF infrastructure and the implementation of modifications will continue. CAR will lead in the preparation of the next major WRF release.

UPDATES TO SCHEDULE: NONE

Task 10.5.4 Develop, test, implement, and improve the Rapid Refresh.

GSD

Progress on the Rapid Refresh continues. Although there have been some incomplete cycles (model forecast failing to complete to 12h, particularly during normal working hours when the load on Jet is heavier), the number of missed cycles is much less than last summer. This has enabled continued strong effort toward remedying known problems. On 3 November our progress was summarized as part of an ESRL/GSD Technical Review presented in Boulder. The presentation is available at **http://ruc.noaa.gov/pdf/RR-RUC-TR_11_3_2009.pdf .**

With the termination of the 2/3 CONUS HRRR runs in early November (the full CONUS HRRR runs on nJet), the path was opened to put the RR cycles into reservations on w/hJet. We are currently working on strategy toward keeping the number of processors reserved for RR use (including both the primary and the dev RR cycles) as uniform as possible through the day, whilst simultaneously ensuring that enough processors are available to reliably run both the primary and dev RR cycles. A complication is the partial-cycling requirement for the "pre-forecast" periods (03 – 09z and 15-21z), initialized (excepting the land-surface fields, which are always cycled with the RR) from the 3-h GFS forecasts at 00 and 12z. For now, the partial cycling is being used only with the primary RR cycle. We are also considering running the primary RR to 18h at certain times of the day, since the RR, when it becomes operational at NCEP, will be run hourly to 18h (see Task 1 for discussion of progress toward the 18-h RUC.)

Results from the partial cycling continue to result in improvement over the RUC in wind and temperature at all levels. (Figure 1 below: Top image 200-400 hPa layer 3h forecast – RMS wind vector error vs. raobs. Lower – same but for 700-900 hPa layers. Partial cycling implemented on 4 October 2009.)

The previously reported boundary problem in the RR is not a significant issue now that partial cycling is being used. Nevertheless, we continue to investigate it since it is probably causing some degradation in the verification scores. We are now quite certain that this comes about because the time tendencies from the external model (in our case, the GFS) are not updated in the WRF model using the latest analysis fields. We have discussed this

matter with NCAR. At their suggestion, we are modifying and testing a WRFVAR routine, update_bc, to recalculate these boundary and blending-zone tendencies inside the WRF model to be consistent with GSI analysis increments and DFI-produced changes, taking into account also that our cycling is more frequent than the 3h-frequency at which the external model forecast fields are available.

Tanya Smirnova continues to add RUC options to the NCEP WRFpost-processor (WPP). Most recently she implemented the RUC algorithms for precipitation type. Based on limited experience so far, these algorithms applied to the RR are giving similar results to the RUC in areas of mixed, freezing and frozen precipitation. Discussions were held at NCEP in early December in conjunction with the NCEP Program Suite Review toward merging the GSD additions and enhancements into the new NCEP Unified post program, which has replaced the WPP for the global model and will become the standard post-processor for the regional models in 2010.

NCEP

Dennis Keyser reports that experimental Rapid Refresh (RR) PrepBUFR files with 50 km ASCAT and WindSat data (non-superob) continue to be generated at NCEP and copied to a private ESRL directory on the NCEP ftpprd server. Up until the instrument reached its end of life on 23 November, expanded (time-window) QuikSCAT data (0.5 deg lat/lon superobs) had also been included. The QuikSCAT data had already been turned off in the global and NAM GSI and RTMA analysis in October. RR dumps of expanded (time-window) Level 2.5/3 88D radial wind data continue to be copied to a public ftp directory. These and hourly lightning data are being tested in ESRL's experimental RR runs. Future data tests will include Multi-Agency Profiler winds and METOP-2 radiances. EMC and GSD request that the ROC start their hourly processing of Level 2.5 88D data 10 minutes earlier so more data will arrive before the RR cutoff. This is critical for the Alaska portion of the expanded RR domain, where the only source of radial wind data is the Level 2.5/3. Alaska Region and Pacific Region are engaged in discussions to provide NCEP with their Level II full resolution data as well.

Subtasks:

10.5.4.1 Ongoing (GSD, NCEP)

Ongoing evaluation of performance of real-time and retrospective runs of RR system for SAVs, AHPs.

The partial cycling primary RR cycle continues to show performance that is equivalent to or better than the backup RUC running at GSD for wind and temperature when measured against rawinsondes. For November and early December, RMS vector wind errors at all levels at 3 and 12h are consistently better by up to 0.5m/s or so than the RUC backup, and RMS temperature errors are similar. There is a small high bias on wind speeds at most levels for the RR1h, and a small warm bias in temperature.

10.5.4.2 1 Nov 2009 (GSD, NCEP)

Continue to solicit input from Inflight Icing, Turbulence, National Ceiling/Visibility, and Convective Weather RTs and NWS forecasters in Alaska and Puerto Rico, as well as AWRP RTs, on performance of pre-implementation Rapid Refresh.

GSD continues to make many different types of RR files available to users (AWR RTs, NWS). We are currently producing 4 flavors of RR files (native level, pressure level, surface field, and precip fields) for each of 3 grids (full RR, Alaska 249, CONUS) and in grib1 and grib2 formats. Per a NWS Aviation Testbed meeting in November in Kansas City, the RR will produce two primary output files:

1. native level 3-d files plus all 2-d fields (land-surface, precip, others), including 2-d diagnostic fields
2. pressure level 3-d files plus all of the same 2-d fields

It was agreed (NWS, NCEP, AWRP PDTs) that these RR files will meet all known requirements.

10.5.4.3 30 July 2010 (GSD, NCEP, NCAR)
Updated report on status of tactical planning for making RR-WRF ARW model code for 2013 in compliance with Earth System Modeling Framework (ESMF) in agreement with the Sept 2007 Rapid Refresh MOU between NCEP and GSD. Work in this area will commence in FY11.

Stan Benjamin, Steve Weygandt and Ming Hu visited NCEP in early Dec. and discussed (with Geoff DiMego, Dennis Rogers, Matt Pyle, Geoff Manikin) scripting, post-processing and other issues related to future NEMS-based RR-ensemble. There was agreement to build from a common set of scripts (initial work by Eric Rogers) and the common NCEP unified post-processor program.

10.5.4.4 31 Mar 2010 (GSD, NCEP)
Complete pre-RFC evaluation of Rapid Refresh in accordance with NCEP pre-implementation checklist for major implementations. Respond to evaluation questions, present information on Rapid Refresh pre-implementation testing and evaluation results in various forums, as required.

An NCEP Charter document for the Rapid Refresh implementation was completed on 10 Dec 2009 and submitted to NCO via Geoff DiMego.

Deliverables:

10.5.4.E1 20 Dec 2009 (GSD)
Report on Rapid Refresh testing at annual NCEP Production Suite Review meeting.

Stan Benjamin, Steve Weygandt and Ming Hu attended the NCEP Production Suite Review 8-10 December and gave an update on RR progress. This presentation can be found at
http://www.emc.ncep.noaa.gov/annualreviews/2009Review/presentations/Benjamin-Weygandt-RUC_C.ppt

10.5.4.E2 1 Aug 2010 (GSD, NCEP)
Complete documentation (in Technical Procedures Bulletin-like document) of Rapid Refresh system.

10.5.4.E3 1 May 2010 (GSD, NCEP)
Pending EMC, and NCEP Center initial recommendations, Requests for Change (RFCs) are filed to submit Rapid Refresh software to NCO.

Task 10.5.5 Develop, test, and implement improvements to the operational data assimilation supporting Rapid Refresh and North American Mesoscale runs.

GSD
Ming Hu conducted a detailed comparison of RR and RUC cloud analysis and forecast differences and identified a few key additional changes needed in the RR cloud analysis code within GSI. With these changes included, RR cloud analyses and forecasts outperform those from matched RUC runs. Results from the RR partial cycling continue to indicate superior performance to the RUC for upper-level wind and temperature. Upper level forecast moisture scores are similar. Surface verification scores indicate a warm, moist bias in the 3-h RR forecast. While much of this bias is likely due to inadequacies in the model boundary layer physics, assimilation of pseudo-observations through the boundary layer may be helpful in reducing the bias. Work within the GSI to implement this RUC-based pseudo-observation assimilation throughout the boundary layer is temporarily on hold due to the

death of our colleague, Dezso Devenyi. During our recent visit to NCEP, we had helpful discussions with Wan Shu Wu, Shun Liu, Dave Parrish, and Manuel Pondeca.

NCEP

Wan-Shu Wu worked on an extension of the adaptive tuning (Deroziers et al.) to adjust not only the observational error covariances but also the magnitudes of background error variances. It was found that the method was also usable in adjusting the structures of the background error covariances. Negative local penalties were observed when suboptimal structures were used. She worked to test & submit new data to the official parallel run by Eric Rogers. The new data included HIRS4 and AMSUA from NOAA 19, IASI from METOP-A, and AMSUA from AQUA and humidity from ACARS. The off line parallel is now being used to test the retuned background error covariances.

Dave Parrish continues to work towards a working regional dynamic constraint. Unfortunately, performance as measured by guess fit to observations after 12 hours of assimilation is still slightly worse when compared to the current constraint and both are a bit worse compared to no constraint. In preparation for the eventual regional data assimilation using ensemble information, the hybrid ensemble method (Wang et al. 2008) has been installed and tested in GSI. This development has been done in collaboration with Xuguang Wang. The code does not yet read ensemble perturbations. For testing purposes, ensemble perturbations were generated internally from random vectors sampled from the existing fixed background error.

Manuel Pondeca has set up a routine cross-validation capability for the RTMA, where the cross-validation datasets are selected with the help of a Hilbert curve-based scheme developed by Jim Purser. He has also made improvements to the Cressman analysis used as the baseline against which the quality of the RTMA is evaluated.

CAPS

Subtasks:

10.5.5.1 30 Nov 2009 (CAPS, NCEP)
Refine the radial velocity analysis component of GSI and determine the optimal decorrelation scales for different analysis passes.

Additional experiments and evaluations were performed at CAPS with the 16 June 2009 test case, including level-2.5 super-obed radial velocity data and reflectivity data.
Four experiments were formed for the 13-km RR grid to examine the impact of different horizontal correlation scale of the radar radial velocity data on the forecast: first using default value as the current RR GSI parameters setting; and second using half of default value; and third using 1/4 of default value; and last using 1/8 of default value. Consistent with earlier results, reduced correlation scales perform somewhat better. 1/4 of the default value is recommended.

10.5.5.2 28 Feb 2010 (GSD)
Report on statistical evaluation of pre-implementation Rapid Refresh forecasts initialized with the GSI, including examination of upper-level winds, surface fields, and precipitation.

Detailed evaluation of RR forecasts, including upper-level fields, surface fields, and precipitation fields was completed as part of a GSD internal review of the AMB branch. Results (see slides 82-86 in the RR-RUC Technical Review PowerPoint from (**http://ruc.noaa.gov/pdf/RR-RUC-TR_11_3_2009.pdf**), were very encouraging, with RR upper-level wind and temperature skill equal or better than RUC at virtually all levels. RR

upper-level moisture was similar to RUC, but a bit worse at some levels. Surface verification was also encouraging for the RR, with scores similar to the RUC for temperature, dew point and winds.

A further report on the Rapid Refresh and RUC development ant testing was presented to a much wider audience the NCEP Production Suite Review meeting on Tuesday 8 Dec 2009.
Available at **http://www.emc.ncep.noaa.gov/annualreviews/2009Review/presentations/Benjamin-Weygandt-RUC_C.ppt**

10.5.5.3 31 May 2010 (NCEP, GSD)
Report on testing of 2DVAR GSI assimilation of high spatial and temporal mesonet surface data using analysis grids with 2.5-km or finer resolution.

10.5.5.4 30 June 2010 (NCEP)
Establish hourly cycled NDAS-like assimilation system on NOAA R&D computer at NCEP (machine called "vapor") using GSI and NMMB within NEMS to be adapted to a NEMS- and ARW-based RR by GSD.

10.5.5.5 31 July 2010 (NCEP)
If authorized by NCEP Director, implement initialization of HiResWindow runs using CAPS/Shun Liu improved techniques for radial velocity analysis in GSI together with Diabatic Digital Filter use of 88D reflectivity Mosaic.

10.5.5.6 31 July 2010 (NCEP)
Based on case-study testing and refinement of the research quality code, deliver results in an 'experimental' code for an upgrade package (e.g. improved satellite channel bias correction, improved use of WSR-88D radial wind and/or satellite radiances and/or retuned co variances to the GSI for FY2011 change package to the NAM.

10.5.5.7 30 Sept 2010 (GSD)
Report on testing of FY11 version of GSI for FY11 Rapid Refresh upgrade.

Deliverables:

10.5.5.E3 31 Dec 2009 (GSD, CAPS)
Further refinement to the radial velocity analysis component of GSI for Rapid Refresh configuration.

GSD had discussions with Shun Liu at NCEP about availability of level II data in real-time. Because the level II data files are very large, GSD has focused thus far on use of level 2.5 data. Data latency issues with the 2.5 data has so far restricted use to be for retrospective tests. With appropriate time thinning of the data, there appear to be no technical barriers to creating hourly level II files (which will not have the time latency issue) and we will be discussing this with Dennis Keyser.

See discussion in 10.5.5.1

10.5.5.E2 28 Feb 2010 (GSD, NCEP)
Complete report on Rapid Refresh performance, including that from the GSI component of the RR, in comparison with the operational RUC.

A detailed comparison of RR and RUC was completed in preparation for a GSD internal review of the AMB group, including upper-level, surface and precipitation verification. Details are in slides 82-91 in

(http://ruc.noaa.gov/pdf/RR-RUC-TR_11_3_2009.pdf) and summarized in 10.5.5.2.

Complete with 8 Dec 2009 presentation at NCEP Production Suite Review meeting:
http://www.emc.ncep.noaa.gov/annualreviews/2009Review/presentations/Benjamin-Weygandt-RUC_C.ppt

10.5.5.E3 1 May 2010 (GSD, NCEP)
Pending EMC, and NCEP Center initial recommendations, Requests for Change (RFCs) are filed to submit GSI code as part of Rapid Refresh software to NCO.

10.5.5.E4 31 Aug 2010 (GSD, CAPS)
New version of GSI including revised radial wind assimilation for FY11 RR upgrade.

10.5.5.E5 30 Sept 2010 (NCEP)
Subject to NCEP Director approval, implement NEMS/NMMB version of GSI (e.g. strong constraint, revised bkgs+obs errors) in NAM/NDAS.

PROBLEMS/ISSUES ENCOUNTERED OR ANTICIPATED:

A key scientist in the Rapid Refresh/RUC group at GSD, Dezso Devenyi, died suddenly on 26 November 2009. We will seek another experienced data assimilation scientist to fill that gap. We do not believe that this will significantly delay the Rapid Refresh implementation in 2010, given what had already been accomplished by Dezso, Ming Hu, and Steve Weygandt. But finding a very effective scientist will be essential for subsequent progress with the RR and HRRR and will be a critical task for early 2010.

Task 10.5.8 Improve physical processes in the WRF (RR and HRRR) and NAM models, especially including those that affect aircraft icing.

Subtasks:

10.5.8.1 30 Nov 2009 (GSD)
Complete systematic GSD evaluation of physics performance in GSD 1-hour RR cycles for initial RR implementation.

The overall performance of the RR WRF physics configuration was completed as part of the November (GSD Tech Review) and December (NCEP model review) meetings. The behavior of the physics (a critical component) appears to be very good, with the RR model now producing at least equal results to the RUC in all key areas (upper-level wind/temp – better, surface wind/temp/Td – about equal overall, precipitation – better for CSI, perhaps too high for bias, ceiling – better for MVFR and IFR conditions). Additional evaluations will be conducted up to the transfer of RR code to NCEP/NCO, but these results including the physics now appear adequate.

The Rapid Refresh will be upgraded to WRFv3.2 when it comes out in January 2010. WRFv3.2 will include some improvements to the Thompson microphysics and RUC land-surface model. An RR retrospective test of the MYNN vertical mixing (boundary-layer) scheme with enhancements to the mixing-length formulation is still planned. We are looking particularly for evidence of beneficial impacts on prediction of low level wind and temperature, and amplitude of the diurnal cycle of temperature, as compared to the MYJ currently used in all the GSD RR cycles.

10.5.8.2 30 July 2010 (NCAR/RAL)
Report on research and testing on addition of the new explicit aerosol variable(s) in initiating cloud water and ice. Computer storage and run time considerations will be considered as a constraint on the development.

10.5.8.3 1 April 2010 (GSD)
Test and evaluate upgrades of RUCLSM to handle sea ice and snow cover on sea ice under wintertime conditions for FY11 Rapid Refresh upgrade.
The new version of the RUCLSM with the explicit prediction of sea ice temperature and its effects on sea ice albedo, as well as accumulation and ablation of snow on the sea ice, continues to run in the RR at GSD. Impacts over Alaska are being monitored as we head into the winter season. So far, performance has been satisfactory. NCAR has accepted these enhancements for submission to the WRF svn repository and they will be part of the WRF v3.2 release due early next year.

10.5.8.4 1 Aug 2010 (GSD)
Continue exploring possibilities for enhancing treatment of sea ice and tundra (including albedo changes and spring-time ponding) in Rapid Refresh domain toward a FY11 Rapid Refresh upgrade.

10.5.8.5 30 July 2010 (NCAR-RAL)
Evaluate the new aerosol based ice initiation scheme that was implemented into WRF during the previous year using available case studies, including ICE-L and IMPROVE II.

10.5.8.6 30 Aug 2010 (NCAR-RAL)
Develop a scheme to explicitly predict the number of cloud droplets based on an assumed aerosol/CCN spectrum. This includes testing various droplet activation schemes in the recent literature based on updraft, general turbulence characteristics, super saturation, and aerosol properties. These changes will enable improved prediction of the size distribution of water droplets, including when freezing drizzle will occur.

10.5.8.10 30 Sept 2010 (GSD, NCAR)
Begin testing at GSD of latest version of microphysics for Rapid Refresh upgrade in FY2011.

Deliverables:

10.5.8.E2 1 May 2010 (GSD)
Pending EMC, and NCEP Center initial recommendations, Requests for Change (RFCs) are filed to submit upgraded WRF model physics code as part of Rapid Refresh software to NCO.

10.5.8.E3 30 July 2010 (NCAR)
Provide an improved microphysics scheme to GSD for evaluation toward the FY11 Rapid Refresh upgrade.

CURRENT EFFORTS:
Work continued on integrating the Dust/Aerosol climatology into WRF for boundary and input conditions. The WRF boundary code was not written to include boundary conditions for scalars (dust and aerosol are defined as scalars), and thus the problem had to be identified and corrected. The new Dust/Aerosol climatology is also being used by Greg Thompson in the development of droplet activation by aerosols in the Thompson microphysics code. A poster on this work will be presented at the International Aerosol Modeling Algorithms (IAMA) conference in Davis in December.

PLANNED EFFORTS:

Continue testing the new aerosol scheme.

PROBLEMS/ISSUES ENCOUNTERED OR ANTICIPATED:
None

INTERFACE WITH OTHER ORGANIZATIONS:
GSD

UPDATES TO SCHEDULE:
None

Task 10.5.15 Develop improved methods of cloud and moisture analysis for use in the Rapid Refresh and NAM Modeling Systems.
GSD

Subtasks

10.5.15.2 5 Jan 2010 (GSD)
Complete improved version of generalized cloud/hydrometeor assimilation (including GOES cloud-top data and METAR cloud/visibility/weather data) within a cycled GSI on the full Rapid Refresh domain.

A number of improvements have been made to the RR/GSI cloud analysis, including moving the cloud analysis after the variational solver, so that modifications made by the cloud analysis are retained within the final analysis fields. In addition, Ming Hu and Stan Benjamin have conducted a detailed evaluation and comparison of the RR/GSI cloud analysis with that from the RUC, and have identified and resolved a number of small differences between the RR and RUC cloud analyses that were degrading the RR cloud analysis skill scores. As a result, POD and TSS scores for both analyses and 1-h forecasts have improved recently for the RR and are now very competitive with the RUC (see Fig.4 below). These improvements were first introduced in to the RRdev cycle, and then ported to the RRprim cycle. Additional work by Ming Hu in late November has further improved the RR cloud analysis so that it is outperforming the RUC for IFR and MVFR ceiling forecasts.

We continue to assimilate experimental NASA Langley satellite-derived cloud-top data into the RRdev cycle. These data provide much more extensive coverage over Canada and Alaska, and the tropical Pacific and Atlantic Ocean regions of the RR domain. Qualitative evaluation of results indicates that introduction of these data help to reduce a high bias in high-level cloudiness of the tropical ocean regions.

Further improvements to the RUC/RR cloud analysis have been developed including, for the first time, allowance of partial cloudiness from the background 1h forecast in the vicinity of METAR stations. Also for the first time, innovations (observation-background differences) for clouds using the background grid column nearest to each METAR station are being used. This new code will be moved into GSI by early 2010.

10.5.15.3 30 Jan 2010 (GSD)
Complete improved diabatic digital filter initialization (DDFI) in the 13-km RR WRF model including assimilation of radar reflectivity data

Assessment of the RR DDFI reflectivity assimilation continues, including evaluation of retrospective case study results and summertime precipitation skill scores. Results look good overall, but some adjustment to the strength of the latent heating forcing may be made. Tests are now underway with the latent heating reduced by 50% in the development version of the RUC. HRRR tests will be performed using initial conditions from the devRUC compared to the usual configuration with the backup RUC. We hypothesize that this will result in less "shattering" of 2-3h HRRR reflectivity fields, an intermittent weakness in 2009 HRRR forecasts.

Deliverables:

10.5.15.E2 1 May 2010 (GSD)
Complete testing of GSI generalized cloud analysis for Rapid Refresh and deliver code to NCEP as part of Rapid Refresh package delivered to EMC, pending availability of NCEP testing capability.

10.5.15.E3 30 Aug 2010 (GSD)
Complete testing of revised cloud analysis for part of FY11 change package to Rapid Refresh

Task 10.5.24 Develop, test, and improve the 3-km WRF-based High-Resolution Rapid Refresh

Subtasks:

10.5.24.1 15 Jan 2010 (GSD, NCAR/RAL, NCAR/MMM)
Design the assimilation/modeling configuration for the HRRR during the 2010 summer convection forecasting (CoSPA) exercise.

Real-time hourly 12-h CONUS HRRR forecasts continue to run on the JET supercomputer with files transfer to NCAR, MIT/LL and other users. Some minor adjustments of the scripting and run configuration (including possible use of quilted I/O) to further optimize run-time are being explored.
The HRRR dedicated disk is now in place and work continues on the agreement to acquire additional dedicated cores. The assimilation configuration for the 2010 will very likely include a second pass of the diabatic DFI-filter-based radar reflectivity assimilation. This 2nd pass filter has been evaluated in case study mode this past summer and gives a big improvement in the first few hours of the forecast. The changes are easy to implement (uses existing code) and will only add a few minutes to the runs time. Additional testing will be completed with implementation into the real-time HRRR early in 2010.

10.5.24.2 15 Aug 2010 (NCAR/MMM, GSD)
In collaboration with GSD, NCAR/MMM will work to evaluate convection-permitting (e.g., 3-km) forecasting by the ARW core for ultimate application in the HRRR. It will perform and evaluate convection-permitting forecasts using the radar-enhanced RR (13-km) grids from GSD for initial conditions, in order to identify strengths and weaknesses of the model at high resolution. This will include analyses, for selected cases, of the evolution of convective storm mode during first 1–3 hours of model transition from 13-km resolution to 3-km resolution. NCAR will collaborate with GSD in the process and submit a summary of results.

This work is ongoing in conjunction with NCAR personnel (including David Dowell, Jenny Sun, Mei Xu, James Pinto, Jimy Dudhia), with monthly meetings to exchange information. Issues that have been examined include domain size, grid-resolution, and choice of background grids, microphysics options, and surface temperature biases

(Related to model post-processing). In additional, as part of the 2009 retrospective verification, GSD is re-running specific cases (09 through 15 UTC, 29,30,31 July) and transferring files to NCAR and MIT/LL for CoSPA retrospective processing.

10.5.24.3 30 Sept 2010 (GSD, NCAR/RAL)
Complete 2010 HRRR summer exercise using modeling and assimilation modifications determined in 2010 exercise. Collaborate on analysis of HRRR tests and deliver summary of results.

10.5.24.4 30 May 2010 (NCAR/RAL)
Conduct sensitivity runs with respect to physical parameterization schemes and initial conditions for multiple high-impact weather days, collaborating with ESRL/GSD. Examine possible reasons for forecast success (or not) for these cases with regard to storm location, timing, intensity, and structural organization.

David Dowell, Mei Xu, and Jenny Sun have conducted a series of sensitivity experiments and completed real-time verification work, which will be presented at the CW PDT science meeting. Barry Schwartz and Steve Weygandt have completed HRRR reflectivity verification at a series of coarsened scales. Results confirm two expectations. First, significant "neighborhood skill" exists indicating that the HRRR often produces storms that suffer only a minor phase error for observed counterparts and that these small phase errors significantly degrade the skill measured on the native grid. Second, this near miss phenomenon is worst just after convective initiation time, when storms are very small-scale.

10.5.24.5 30 July 2010 (GSD)
Analyze and evaluate the results with regard to sensitivity for prediction of turbulence, icing, and winter weather (including ground de-icing) conditions. Collaborate with relevant RT members on evaluation of results. The CONUS HRRR now in planning for FY10 will be particularly strongly tied to the Turbulence RT and allows a HRRR-based GTG, especially for mountain-induced turbulence. This additional 0.5 FTE support will facilitate this interaction also.

We are in communication with the other RTs (beyond CW) about transferring HRRR files for examination.

Deliverables:

10.5.24.E1 30 Sept 2010 (GSD)
Complete FY10 test (likely with full CONUS domain) with 3-km High-Resolution Rapid Refresh running every 1 h.

- **Conduct real-time summer 2010 HRRR forecasts using 3-km WRF initialized with radar-enhanced Rapid Refresh over full CONUS domain, monitor performance, modify code/scripts as needed, maintain high reliability working with ESRL computer facility**
- **Coordinate with other AWRP users and other collaborators, including coordination of HRRR grid transfers**
- **Provide project management**
- **Lead writing of report on summer 2010 HRRR experiments**

In late Oct. 2009, GSD began running in real-time an hourly cycled CONUS HRRR. The CONUS HRRR runs take about 50 min. of wall clock time on 840 cores. GSD worked with NCAR and MIT/LL too make sure cut down (2/3 CONUS) versions of the key HRRR output files were in place to allow uninterrupted product generation as

CoSPA is switched to full CONUS. Following this checkout, the GSD 2/3 CONUS HRRR runs were discontinued. Work is ongoing to further optimize the HRRR code and scripts for reliability and runtime.

10.5.24E2 30 Sept 2010 (NCAR/MMM)
Collaborate with GSD on analysis of convection-permitting forecast cases for 3-km ARW initialized with RUC-RR radar-initialized DFI grids. Draft and deliver summary of conclusions and results.

Work ongoing with monthly meetings. See discussion in 5.24.2

10.5.24E2 30 Sept 2010 (NCAR/RAL)
Deliver report summarizing all HRRR experimental results on sensitivity to physical parameterizations, initial conditions and assessment of HRRR results for key case studies from high impact weather days.

10.5.24.E3 30 July 2010 (GSD)
Complete a report on initial applications of HRRR forecasts to icing, winter weather, and turbulence forecasts.

Task 10.5.19 Develop and refine techniques to assimilate radar radial velocity and reflectivity data through GSI and Rapid Refresh toward the HRRR.

GSD
See below under subtasks.

NCEP
Shun Liu has integrated codes for dumping BUFR format VAD winds into the radar quality control package. CCS jobs and scripts were modified to generate a VAD wind BUFR tank and are undergoing parallel tests. A new 2009 version of the radar quality control package is being tested. The LAPACK library is used in the NSSL QC codes is not available on NCEP's super computer, so Shun has adapted the QC codes to use similar subroutines in the ESSL libraries on NCEP's supercomputer as a replacement for those in LAPACK. Occasional test runs initializing 4 km runs of NMM with the extended GSI use of radial winds continue.

Shun Liu reports the 2009 version of Level-II radar data QC package is under parallel testing. The LAPACK library is used in the original NSSL codes but is not available at NCEP. Similar subroutines in the ESSL on NCEP's supercomputer were used to replace LAPACK. Test results showed that the impact is very small after replacing LAPACK with ESSL. The 2009 QC also rejects too many radar observations; the reason is under investigation. The new QC also runs slower than the QC package in operations. Efforts were made by EMC and NSSL to remove unnecessary codes and simplify some other codes in the new QC package. The code for dumping BUFR format VAD wind was integrated into QC package. Job scripts were modified to generate the VAD wind BUFR tank and are in parallel testing.

CAPS

NCAR/RAL

Subtasks

10.5.19.1 1 Dec 2009 (GSD, NCAR/RAL, CAPS)
Select initial case studies from summer 2009 for 3-km HRRR data assimilation case studies.

GSD has re-run specific cases (09 through 15 UTC, 29, 30, 31 July) selected in conjunction with NCAR and MIT/LL for high weather-related aviation impact. Output has been transferred to NCAR and MIT/LL for CoSPA retrospective processing. GSD also worked with CAPS to select a mini-retrospective case study period (June 15-16, 2009). This period has initially been used for Rapid Refresh testing of reflectivity and radial velocity assimilation, but will also be used for follow-up 3-km HRRR assimilation testing. Lastly, a specific case study period (June 17, 2009) was selected for use in initial tests of the 3-km diabatic DFI-based reflectivity assimilation.

10.5.19.2 31 August 2010 (GSD, NCAR/RAL)
Run case studies from 2009-2010 using 3-km HRRR on GSD jet computer using different RR-based initial conditions

- **Radar-DFI enhanced RR**
- **Test of 3-km radar-enhanced diabatic digital filter initialization (DDFI)**

Initial work ongoing for 3 different case study test periods. See description in 5.19.1

10.5.19.3 30 Sept 2010 (CAPS)
Complete new 3-km GSI data assimilation experiments toward improved assimilation of radial wind.

Early experiments using different cloud analysis options – the stratiform option originating from RUC cloud analysis system and the convective option originating from ARPS cloud analysis, showed that the stratiform method is slightly better when the initial time was at the development stage of the MCS, while the convective option performs clearly better when initializing at the mature stage. The difference becomes smaller during the dissipation stage. To take the advantages of both methods, the cloud analysis package is modified to choose the cloud analysis scheme based on an objective classification of precipitation type. It is based on the algorithm of Steiner et al (1995, JAM). The Steiner method identifies convective areas as meeting the one of the following criteria: (1) RefZ3km (reflectivity at 3 km height) > 40dBz; (2) RefZ3km-Z_{bg} > 10 – Z^2_{bg}/180, where Z_{bg} is the average of 3-km reflectivity within 11 km radius in horizontal; and (3) grid points within an intensity-dependent radius around the points meeting the above two criteria. Because of the relatively coarse resolution of RR, we only apply rules (1) and (2). However, in this study, most of the precipitation areas are classified as stratiform region. Therefore, the forecast results are more like those obtained with pure stratiform option. Similar experiments will also be performed on the HRRR grid. The classification method is two-dimensional which is which the cloud analysis schemes need - the convective cloud analysis scheme considers the entire column when making temperature adjustment.

In addition, experiments of higher resolution (4 km, 3 km later for match HRRR resolution) nested in the RR grid were performed. The RR forecasts assimilating conventional data only were used to provide boundary conditions. The experiments used the same options as the current RR except that the cumulus physics option is turned off. Hourly assimilation cycles were performed over a 12 hour period, with the first analysis performed at 18 UTC, June 15, 2009, using 3-hour RR forecast from 15 UTC as analysis background. 12-hour forecasts were launched from each of the hourly analyses. For comparison purpose, in a parallel set of experiments, the latest available GFS forecasts (every 6 hours) on #4 domain (0.5 * 0.5 degree, here after GFS4) were used in place of RR to provide initial analysis background and the boundary conditions. The GFS4 analysis cycles were started at 15UTC, using 3-hour forecast from 12 UTC as the initial analysis background. All other settings are the same as in those using RR fields.

Gilbert Skill Scores (GSS, also known as ETS) show that the RR case performed slightly better than the GFS4 case in the first 4-6 hours of forecasts (see Fig.2). After that, the differences become mixed. Over all, the RR fields are slightly better than the GFS4 fields. In the future, the high-resolution experiments will use the same domain and 3-km resolution as the HRRR grid of March 2009, which covers approximately the eastern 2 / 3 of CONUS.

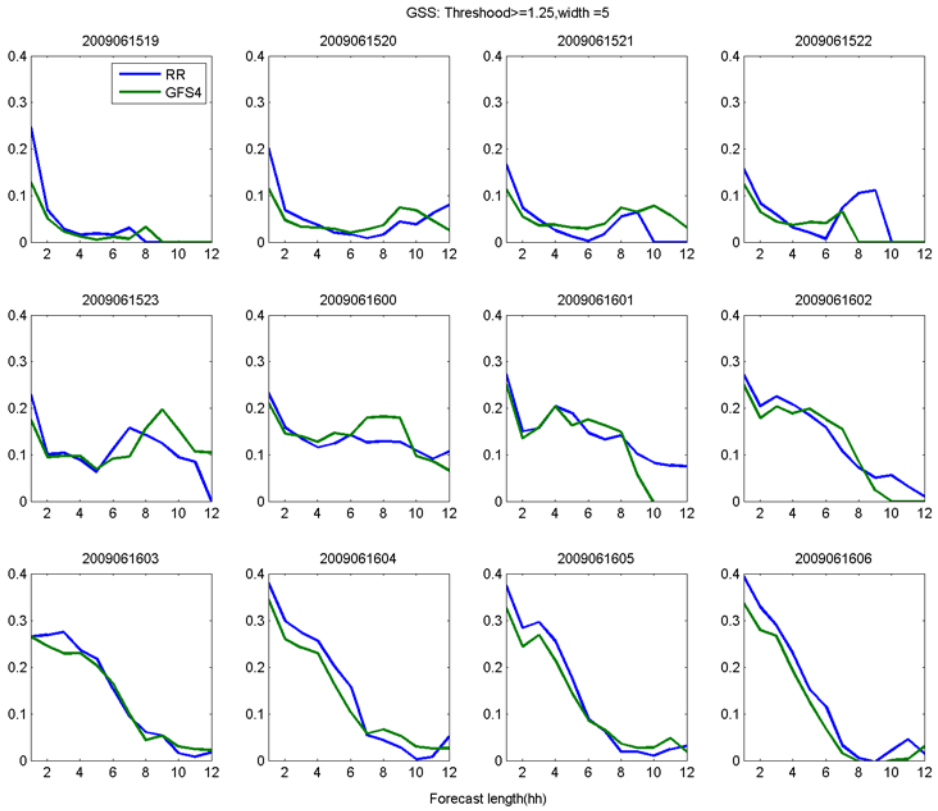

*Fig.2. GSS scores of 4-km-resolution forecasts from hourly cycles assimilating radar data, comparing forecasts using RR versus GFS forecasts as the lateral boundary conditions, and as for the initial analysis background***.**

10.5.19.4 30 Sept 2010 (GSD)
Develop and test improved DFI assimilation of radar reflectivity at 3-km using observation-based specification of latent heating within WRF-DFI developed by GSD and NCAR in FY09.

Case studies to examine the benefit of a 2nd pass 3-km application of the radar reflectivity DFI method was completed for the 17 June 2009 case study. Results were extremely encouraging, indicated that application of the 3-km radar DFI allows latent heating to induce very realistic balanced storms (including hydrometeor fields). This results in a very realistic forecast for the first few hours.

Deliverables:

10.5.19.E1 30 April 2010 (CAPS)
Provide new radial wind assimilation in 13km GSI designed specifically to improve HRRR initial conditions to be applied in summer 2010 HRRR exercise.

10.5.19.E2 30 Sept 2010 (GSD, CAPS, NCAR/RAL)
Report on results from improved version of 13km/3km radar assimilation techniques for demonstration in FY10 exercise.

10.5.19.E3 30 Aug 2010 (GSD, CAPS, NCAR/RAL)
Provide additional report on radar assimilation results for HRRR from winter 2009-10 case studies under the lead of GSD with contributions from each organization.

10.5.19.E4 15 Sept 2010 (NCEP)
Demonstrate mini-NDAS data assimilation system using HRRR-like design constructed to precede HiResWindow runs or Matt Pyle's SPC runs using hourly updates with GSI.

10.5.19.E5 15 Sept 2010 (CAPS, NCEP and GSD)
Report on the design and initial development of EnKF data assimilation for Rapid Refresh scale

Task 10.5.20 Develop ensemble-based probabilistic products for aviation users.

GSD
Doug Koch and Curtis Alexander conducted HCPF sensitivity tests and further examined the HCPF skill and documented the skill improvement by adding additional time-lagged ensemble members. In addition statistical reliability plots were created.

NCEP
Jun Du, BinBin Zhou, and Yali Mao visited AWC on 16-19 November to discuss SREF aviation products. Jun overviewed the NCEP SREF system including its current system configuration, methodology, aviation products and future plans. Binbin talked about the development status of the VSREF products for future NextGen aviation probabilistic products. Jun and Yali talked to AWC duty forecasters to learn how the forecasters are using NWP products and what kind of aviation-specific products they derive. AWC provided a product wish-list for future SREF implementations, organized into three tiers: short (within 1 year), medium (2 years) and long (3 years and beyond) in terms of their availability to the user community.

BinBin Zhou continues to maintain the web page for VSREF and is continuing work on adding fog to the ensemble product generator, variables from SPC and variables for AFWA as well as on SREF's echo-top verification with the mosaic dataset.

Subtasks:

10.5.20.1 28 Feb 2010 (NCEP)
Complete 'research quality' version of upgrade to SREF (e.g. higher resolution, NEMS members, and more physics diversity or stochastic physics) for consideration in November 2010 SREF upgrade package.

10.5.20.2 15 Feb 2010 (NCEP)
NCEP visits AWC to conduct continued training and education on SREF applications, receive feedback on existing guidance, and to acquire new requirements (fully depending on FAA funding).

10.5.20.4 31 Aug 2010 (NCEP)
Based on case-study testing and refinement of the research-quality code, deliver the upgrade SREF codes to NCO for November 2010 SREF upgrade package.

10.5.20.5 30 April 2010 (GSD, NCEP)
Improve preliminary (developed in FY09) procedure appropriate for aviation users from Very Short-Range Ensemble Forecast (VSREF) system using high-resolution RR and NAM existing runs toward a future High-Frequency Probabilistic Forecast (HFProb) generator to be used in NextGen, including common post-processor, obs-based statistical post-processing, optimized member weighting

Steve Weygandt provided code from the RUC Convective Probability Forecast (RCPF) time-lagged ensemble to Binbin Zhou, who has incorporated the algorithm into is SREF infrastructure. Discussion and collaboration is ongoing. Steve met in person with Binbin during an early Dec. visit to NCEP. Areas for possible modification of the VSREF algorithm were identified, including using a statistical method (such as linear regression) to obtain weights for the various time-lagged members and to obtain threshold values for the predictors. Curtis Alexander and Doug Koch have developed a real-time HRRR-based convective probability Forecast (HCPF), which is running on real-time at GSD with web-based display and verification. It was recently switched to run off of the HRRR and provide CONUS coverage. Verification results have been very encouraging.

10.5.20.6 1 July 2010 (GSD, NCEP)
Further calibrate probabilities and potential echo-top (improve statistical reliability) ensemble cumulus information.

Deliverables:

10.5.20.E1 30 June 2010 (NCEP, GSD)
Subject to NCEP Director Approval, implement at GSD initial VSREF product generation for turbulence. Work toward future NCEP implementation [products will not be distributed as Operational but are generated routinely within the RR script as part of NCEP's Production Suite].

10.5.20.E2 30 Aug 2010 (GSD, NCEP)
Demonstrate products from experimental VSREF probabilistic forecasts updated hourly.